ch1 → Introduction.

ch2 → External Flow (theory of Boundary layer).

ch3 → Internal Flow (Flow in Pipes & Ducts).

(Ducts ↓ الأشكال الغير دوراية.)

Hydraulic depth

Hydraulic Radius

$$R_H = \frac{\text{Area}}{\text{Primeter}} = \frac{h * w}{2(h+w)}.$$

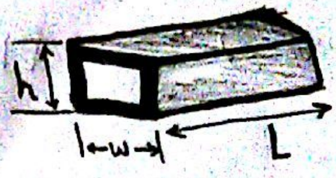
$$Re = \frac{\rho U D}{\mu} = \frac{UD}{\nu}$$

Hydraulic Diameter =

$$D_H = \frac{4 \text{ Flow area}}{\text{wetted Primeter}}$$

$A = h * w$

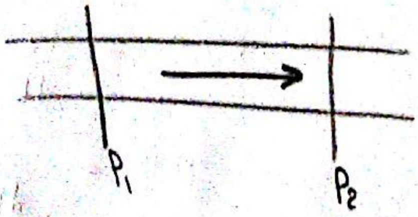
sec. Primeter $= 2(h+w)$




$$D_H = \frac{4 * h * w}{(h+w)}$$

ساعات بيهمل H اللى فى المقام

$D_H = 2h$ ✗




$P_1 > P_2$

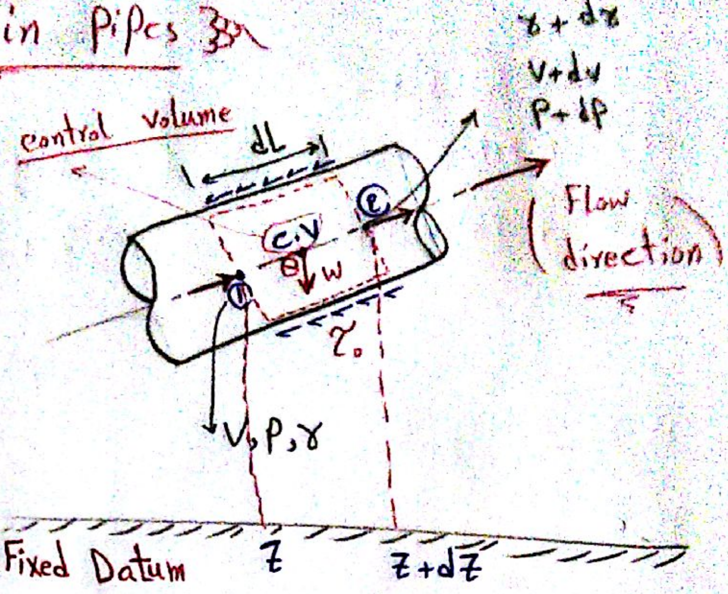
$V_1 = V_2$

$Z_1 = Z_2$

total Energy of Flow $= \left[\frac{P}{\gamma} + Z + \frac{V^2}{2g}\right]$

(b)

# Flow in Pipes




$$dw = (\gamma + \frac{d\gamma}{2}) A * dL$$

moumentum

$$d\,(m\,v)$$

$$m^{\circ} V = v$$

$$m * \frac{dv}{dt} = v \quad \text{mass * accelaration}$$

$S = \pi D$

↑ Primeter

$$m^{\circ} V = PA - (P + dP) A - \tau_{\circ}\, s\, dL$$

$$- (\gamma + \frac{d\gamma}{2}) A\, dL \cdot \frac{dz}{dL}$$

$$\cos\theta = \frac{dz}{dL}$$

$$\sin\theta = \frac{}{dL}$$

$$= [(\rho + d\rho)(v + dv) \cdot A] V_2 - [\rho\, v\, A]\, V_1$$

$$m^{\circ} = \rho A V = (\rho + d\rho) A (v + dv) = \text{Const}$$

$$\gamma = \text{Const} \qquad d\,\frac{1}{\gamma} = 0$$

$$= A (\rho + d\rho)(v + dv)^2 - \rho v^2 A$$

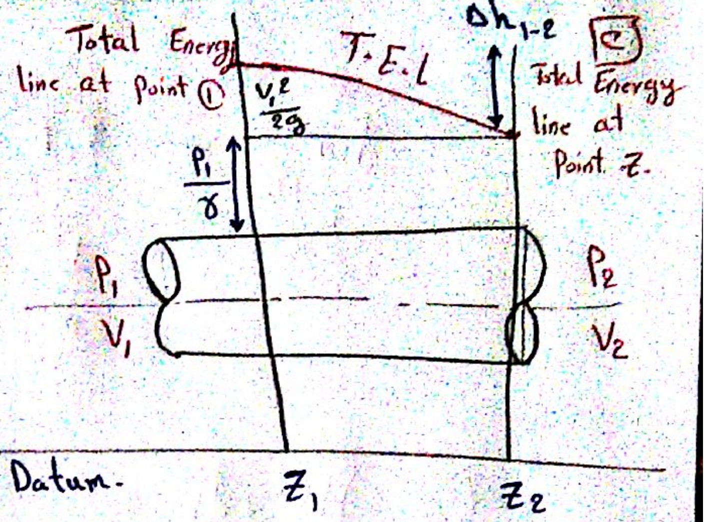
$$\Rightarrow \frac{dp}{\gamma} + d\left(\frac{v^2}{2g}\right) + dZ = \frac{-\tau_{\circ}\, dl}{\gamma R_H}$$

$$= d\left(\frac{P}{\gamma} + \frac{v^2}{2g} + Z\right) = -\frac{\tau_{\circ}\, dl}{\gamma R_H}$$

$$\left[\frac{P}{\gamma} + \frac{V^2}{2g} + Z\right]_2 - \left[\frac{P}{\gamma} + \frac{V^2}{2g} + Z\right]_1 = \frac{-\tau_{\circ}\,(L_2 - L_1)}{\gamma R_H}$$

$$= \frac{2 \tau_{\circ} L}{\gamma * r}$$

$\Delta h_{1-2}$ losses
↑
(Friction losses)




T.E.L
خط أفقي في حالة Ideal flow } ⟶ بسبب عدم وجود المفاقيد .

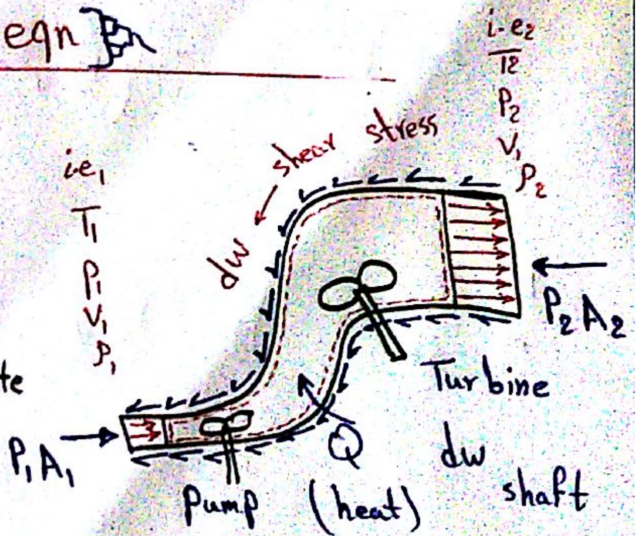
$$R_H = \frac{A}{S} = \frac{\pi r^2}{2\pi r} = \frac{r}{2}$$

$$l_2 - l_1 = L$$

$$\Delta h = \frac{2\tau_0 L}{\gamma r} \Longrightarrow \tau_0 = \left(\frac{\gamma \Delta h}{2L}\right) r$$

## [Bernolli's eqn]

$$\frac{dQ}{dt} + \frac{dw}{dt} = \frac{dE}{dt}$$




$\frac{dQ}{dt} = \dot{m}\, q_H$ ⟶ heat per unit mass flow rate

وحدتها ⟶ (N.m/kg) or (J/kg)

$$dw_{shaft} = (E_p - E_t)\gamma Q = \dot{m} g\, [E_p - E_T] \quad dw_{shaft}$$

$\dot{m} = \rho Q$ [kg/s]

$\dot{w}$ = weight flow rate $= \dot{m} g = \gamma Q$ [N/s]

(d)

$$dw_{Flow} = P_1 A_1 V_1 - P_2 A_2 V_2$$

$$= \frac{1}{m^\circ} \frac{dw_f}{dt} - \frac{1}{m^\circ} \left( \frac{P_1}{\rho_1} - \frac{P_2}{\rho_2} \right)$$

$$E = \iiint i \, dm$$

$E = \iiint i \, dm$ — E: extensiv Properties; i: Intensiv Properties

$$E = \iiint \left( \frac{v^2}{2} + gz + i.e \right) dm$$

$$\frac{dE}{dt} = \iint_{C.S \text{ out}} i(\rho v dA) + \iint_{C.S \text{ inlet}} i(\rho v dA)$$

C.S → Cross section.

$$\frac{dE}{dt} = \iint_{C.S} \left( \tfrac{1}{2} v^2 + gz + i.e \right)(\rho v dA) - \iint_{C.S} \left( \tfrac{1}{2} v^2 + gz + i.e \right) * (\rho v dt)$$

$$\frac{1}{m} \frac{dE}{dt} = \iint_{C.S \text{ in}} \left( \tfrac{1}{2} v^2 + gz + i.e \right) - \iint_{C.S} \left( \frac{v^2}{2} + gz + i.e \right)$$

$$= \left[ \frac{V_2^2}{2} + g z_2 + i.e_2 \right] - \left[ \frac{V_1^2}{2} + g z_1 + i.e_1 \right]$$

$$\frac{1}{m} \frac{dE}{dt} = q_H + (g E_P - g E_T) + \left( \frac{P_1}{\rho_1} - \frac{P_2}{\rho_2} \right)$$

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + z_1 + E_P = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + z_2 + E_T + (ie_2 - ie_1 - q_1$$

$(ie_2 - ie_1 - q)$ = H losses

e)

$$\frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 + E_P = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 + E_T + h_{losses}$$

$$\therefore \frac{P_1}{\gamma} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\gamma} + \frac{V_2^2}{2g} + Z_2 + h_{losses}$$

Bernolli's eqn.